PRELIMINARY ASSESSMENT OF CURRENT AND FUTURE PROSPECTS FOR ONSITE SPECIAL WASTE MANAGEMENT IN ONTARIO

Final Report
April 15, 1988

Submitted to:

VICTOR & BURRELL
720 Spadina Ave., Suite 509
Toronto, Ontario

Submitted by:

ZENON ENVIRONMENTAL INC.
845 Harrington Court
Burlington, Ontario
L7N 3P3

File No. CO873105

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90-02874/

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April 15, 1988 File No. CO873105

Dr. Peter Victor
Victor & Burrell
720 Spadina Ave, Suite 509
Toronto, Ontario

Dear Peter:

RE: OWMC Onsite Waste Management Project

We are pleased to submit our final report entitled "Preliminary Assessment of Current and Future Prospects for Onsite Special Waste Management in Ontario". As agreed, this report incorporates the additional points outlined in your letter dated December 14, 1987.

We trust this report is satisfactory. If you have any questions, please call.

Yours truly,

R. Philip Canning, P.Eng.
Manager, Process Engineering

RPC/bjd
Encl.

cc: A.E. Veel - OWMC

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1.0 INTRODUCTION

1.1 Purpose of Report

ZENON Environmental Inc. has been retained by Victor & Burrell to assist in providing technical input for the preparation of OWMC's Environmental Assessment document. The purpose of ZENON's input is to establish the current and possible future role of onsite waste management activities in Ontario; in particular, to provide Victor & Burrell with technical and cost information for those onsite waste management technologies which were not covered in ZENON's earlier report to OWMC entitled: " In Plant Waste Treatment Processes: Technical and Economic Review", (1986). This information is designed to assist Victor and Burrell in establishing the least cost waste management scenario for Ontario industry. The detailed terms of reference of this work are outlined in Appendix A.

1.2 Scope of Work

This work has concentrated primarily on:

- Assembling and interpreting up to date data and information on site waste management activities from existing published sources in Canada, the U.S., and Europe.
- Identifying and defining the range of waste management approaches which are typical of those used by industries to manage their wastes onsite.
- Assessing available cost data .

This report summarizes the results which have been obtained in each of these areas. The report also outlines in broad terms, the key issues and factors which are expected to affect the implementation of onsite waste reduction strategies as a basis for providing a qualitative assessment of the role that these activities are likely to play in Ontario industries.

The report also defines qualitatively, the expected relationship between onsite waste reduction (% reduction) and cost. Unfortunately, this relationship can not be quantified at the present time because of a lack of available data for establishing such correlations. Similarly, it has not been possible in this report to present unit costs for specific onsite waste minimization technologies such as process modifications and housekeeping because of the case specific and widely varying nature of the limited cost vs. benefit information which is available.

It should be noted that an updated version of Pollution Probe's 1982 report entitled "Profit from Pollution Prevention" (Campbell and Glenn, 1982) is currently being prepared.

Unfortunately, this information was not available at the time of writing. In view of the potential relevance of this report, particularly with respect to waste minimization activities in Ontario, it is recommended that the updated Pollution Probe information be reviewed in the context of the data and information presented in this report as soon as it becomes available.

2.0 TERMS AND DEFINITIONS

2.1 Introduction

A wide spectrum of approaches and technologies are employed in the onsite management of special wastes. Associated with this fact is the use of an assortment of terminologies referring to the various practices and strategies employed. It is therefore necessary at the outset to identify and define the range of approaches which will be considered for this discussion of onsite special waste management practices.

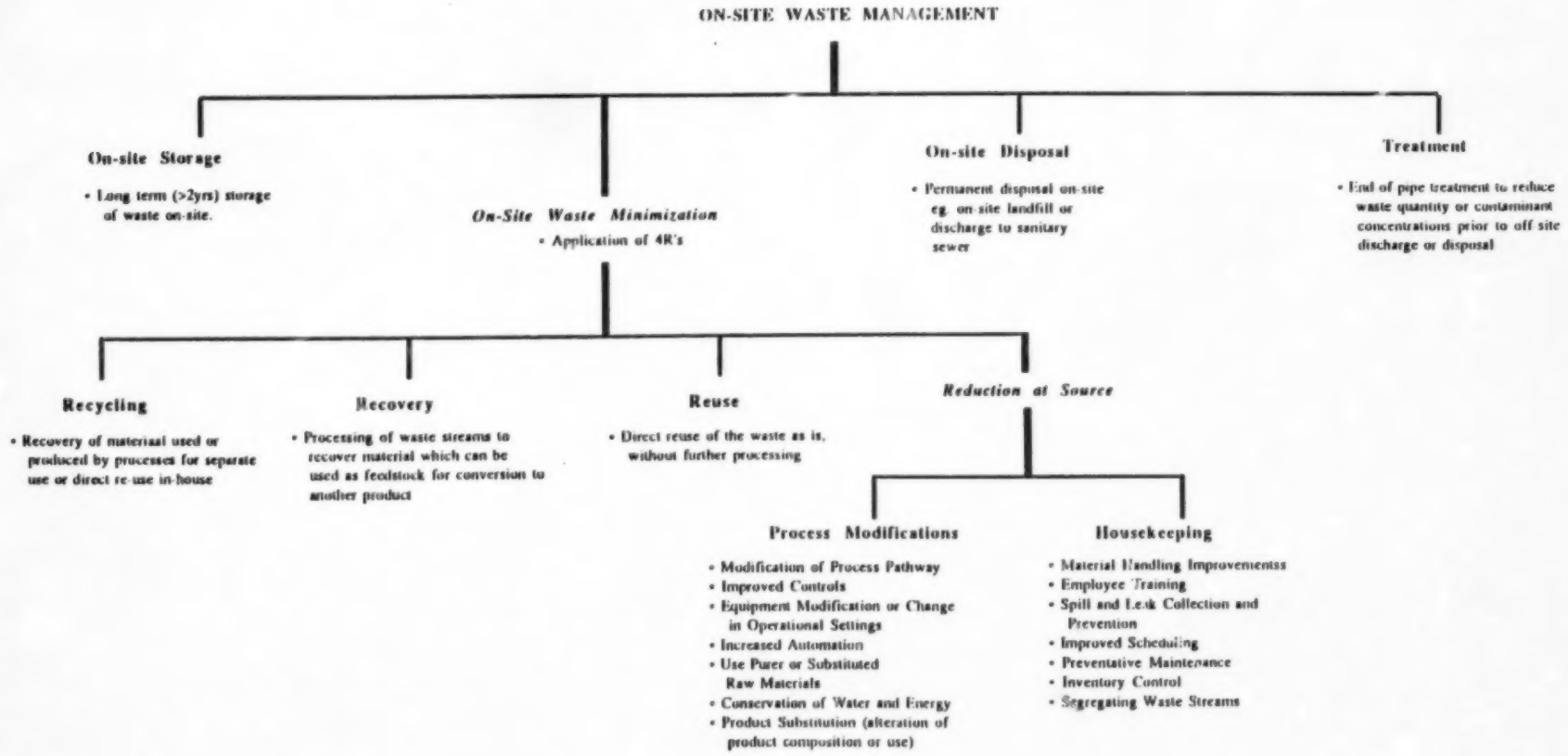
For the purposes of this assessment, the term 'onsite waste management' itself refers to any waste management activities which are carried out within a waste generators' plant boundary which could alter and/or reduce the total quantity of waste which would otherwise be either discharged from the plant into a sewer or receiving water body or, sent offsite for disposal. In practice, onsite waste management activities are generally aimed at either improving the quality of a plant effluent in order to meet discharge regulations or reduce sewer surcharges or, they are aimed at reducing the total volume of waste materials which must ultimately be sent offsite for disposal. For OWMC's purposes, activities such as onsite storage and onsite disposal are included in the scope of onsite waste management activities considered because these practices will also influence the total volume of hazardous waste which will require offsite treatment and/or disposal. In addition to these, there is a range of other onsite waste management activities and component activities which are generally referred to in the literature as "waste minimization" or "waste reduction" practices. These include mainly 4R activities (recycle, reuse, recovery, reduction), which are aimed at minimizing waste discharges.

Versar and Jacobs (1986) have completed a very comprehensive assessment of "waste minimization" and its various components on behalf of the U.S.EPA. Where applicable, the working definitions developed by Versar and Jacobs in their work have been adopted for use in this assessment in order to provide a consistent basis for assessing and interpreting the quantitative data available from this and other literature sources.

These definitions are outlined in the following sections. Figure 2-1 summarizes the components and subcomponents of the various onsite waste management activities which have been used as a basis for establishing the current and future role of onsite waste management in Ontario.

Figure 2-1

Components of On-Site Special Waste Management


ON-SITE WASTE MANAGEMENT
On-site Storage
• Long term (>2yrs) storage of waste on-site.
On-Site Waste Minimization
• Application of 4R's
On-site Disposal
• Permanent disposal on-site eg. on-site landfill or discharge to sanitary sewer
Treatment
• End of pipe treatment to reduce waste quantity or contaminant concentrations prior to off site discharge or disposal
Recycling
• Recovery of material used or produced by processes for separate use or direct re-use in-house
Recovery
• Processing of waste streams to recover material which can be used as feedstock for conversion to another product
Reuse
• Direct reuse of the waste as is, without further processing
Reduction at Source
Process Modifications
• Modification of Process Pathway
• Improved Controls
• Equipment Modification or Change in Operational Settings
• Increased Automation
• Use Purer or Substituted Raw Materials
• Conservation of Water and Energy
• Product Substitution (alteration of product composition or use)
Housekeeping
• Material Handling Improvementss
• Employee Training
• Spill and Leak Collection and Prevention
• Improved Scheduling
• Preventative Maintenance
• Inventory Control
• Segregating Waste Streams

2.2 Definition of Terms

2.2.1 Onsite Storage

Onsite storage of hazardous waste is defined as long term storage (ie. > 2 years). In Ontario, this generally refers to situations where the wastes will eventually be hauled offsite for treatment or disposal once technically or economically feasible treatment/disposal technologies become available. An example of this would be the current practice of temporarily storing PCB containing liquids and solids until an approved method is available for its destruction.

2.2.2 Onsite Disposal

Onsite disposal refers to the use of "permanent" disposal methods on the property of the waste generator such as land filling and/or land farming including wastes which are discharged to a sanitary sewer.

2.2.3 Onsite Treatment

Onsite treatment refers to the end-of-pipe treatment of wastes to reduce their volume or level of contaminant concentration prior to offsite discharge or disposal. Depending on the charactistics of the wastestreams, a wide variety of treatment technologies may be employed to achieve desired treatment criteria. These are listed in Table 2-1 and discussed in detail in ZENON (1986).

Some inhouse special waste management technologies are generally used only for end-of-pipe treatment whereas others are more often used for achieving waste minimization such as recycle or recovery of valuable by-products for inplant use or sale offsite. A few technologies can be used either for waste minimization purposes or, for end-of-pipe treatment, depending on the particular application. Table 2-1 summarizes the more common uses for each of the technologies outlined in (ZENON 1986) as a basis for indicating where potential overlap would exist between end-of-pipe 'treatment' approaches and waste minimization approaches for onsite waste management.

It can be seen from Table 2-1 that evaporation, activated carbon adsorption, oil/water separation by decanter and membrane processes generally have dual suitability, whereas, distillation, ion exchange and solvent extraction are primarily used for waste minimization purposes. In this case, liquid injection incineration without gas treatment is considered a waste

TABLE 2-1

ON SITE TREATMENT TECHNOLOGIES

	Recycling/Recovery Technology	Treatment Technology
- neutralization		◊
- neutralization/precipitation/sedimentation		◊
- neutralization/precipitation/sedimentation filtration		◊
- coagulation/sedimentation		◊
- coagulation/sedimentation/filtration		◊
- sedimentation		◊
- filtration		◊
- precipitation/filtration		◊
- centrifugation		◊
- evaporation	◊	◊
- biological treatment		◊
- wet air oxidation		◊
- liquid injection incineration without gas treatment	◊	
- liquid injection incineration with gas treatment		◊
- rotary kiln incineration with gas treatment		◊
- distillation	◊	
- activated sludge		◊
- sludge farming		◊
- boiler fuel	◊	
- pyrolysis		◊
- activated carbon adsorption	◊	◊
- chemical oxidation		◊
- chemical reduction		◊
- dissolved air flotation		◊
- ion exchange	◊	
- membrane processes	◊	◊
- oil/water separation by decanter	◊	◊
- powdered activated carbon treatment		◊
- solidification		◊
- solvent extraction	◊	

minimization (recycling/recovery) technology because most applications involving this technology would likely also involve the use of recovered hydrocarbons such as slop oils to augment or replace the use of virgin fuel to reduce overall fuel costs (eg. in cement kilns, industrial boilers etc.) It should be noted that although the remaining technologies listed in Table 2-1 are generally used primarily for onsite treatment purposes, in some cases these processes can also be used as pretreatment processes in systems designed to produce treated effluents and residues for onsite recycle or to recover valuable by-products.

The information presented in Table 2-1 indicates that it is not possible to completely separate onsite treatment techniques from waste minimization (recycle/reuse) techniques. Furthermore, there is no basis in the literature for estimating the component of total waste reduction which is likely to result from waste minimization approaches (4 R's process modification or housekeeping) compared to that which can be achieved end-of-pipe treatment. Such information could only be obtained by means of a detailed survey of case histories in Ontario. Such a survey is beyond the scope of the present study.

2.2.4 Waste Minimization

Waste minimization is defined as "the reduction of hazardous waste that is generated or subsequently treated, stored, or disposed of. It includes any source reduction/reuse, recovery or recycling activity undertaken by a generator that results in either (1) the reduction of total volume or quantity of hazardous waste, or (2) the reduction of toxicity of hazardous waste, or both, so long as such reduction is consistent with the goal of minimizing present and future threats to human health or the environment (Versar and Jacobs, 1986).

For the purposes of these evaluations, waste minimization is assumed to consist of the following subcomponents:

- onsite waste recycling, recovery or reuse including recycling of treated effluents
- onsite source reduction of waste which is brought about by:
  - process changes
  - housekeeping

These terms are further defined in the following paragraphs.

Recycling

Internal recycling refers to processes which are aimed at the recovery of materials used or produced by processes for separate use or direct reuse in house. For example, the treatment of process wastewater to enable the treated effluent to be reused in plant is a waste recycling activity.

Recovery

Waste recovery activities refer to waste reprocessing steps which are aimed at recovering components which can be used as feedstocks for making other products. An example would be the recovery of valuable heavy metals from waste sludges for resale. Recovery is distinct from recycling in-so-far as the recovered by-products are not generally reused in house.

Reuse

Waste reuse generally refers to activities involving the direct recycling of wastes and/or effluents without further processing. The use of once-through cooling water for process purposes is an example of waste reuse.

Source Reduction

Source reduction is defined as any activity or treatment that reduces or eliminates the generation of hazardous wastes before they are produced within a process. Such modifications can be categorized into either Process Modifications or Housekeeping measures as follows:

2.2.5 Process Modifications

Process modification is considered to be an effective approach to source reduction for most operations. In general "Process Modification" refers to the use of alternative in-plant manufacturing processes, or changes to the physical plant itself, which will minimize waste production while achieving the same product (Versar and Jacobs, 1986). Components of this approach include:

- Modification of manufacturing process pathway
- Improved process controls
- Equipment modifications or changes in operational settings
- Increased automation
- Use of purer or substituted raw materials
- Conservation of water and energy
- Product substitution (ie. the alteration of product composition or use)

Modification or alteration of the actual manufacturing process pathway, modification of reaction parameters, such as catalyst type and reactor design, and modifications to process parameters in order to maximize process efficiency are all considered to be 'process modifications'. Equipment modifications, either as a result of manufacturing process changes, or carried out without changes in the process itself in order to improve efficiency are also included in this

category. Examples include changing pump seals to minimize risk of spillage and waste, or increasing turbulence to inhibit fouling of heat exchangers. Changes in operational settings of equipment, such as reducing pressure in a spraying operation to minimize overspray and spillage, would also constitute a process modification (Versar and Jacobs, 1986).

Process automation can be used to maximize product recovery and therefore minimize waste by allowing process optimization and closer adherence to ideal process parameters.

Raw material purification or substitution can also facilitate effective waste reduction in some processes by employing feedstock pretreatment, or by substitution of some materials by a higher grade or better quality feedstock. This also applies to secondary materials which are used in the process but which do not become part of the end product.

Water and energy conservation also may contribute, though probably on a smaller scale, to overall waste reduction in some operations. Energy efficient operations can minimize wastes associated with fuel combustion, and raw water treatment, boiler blowdown and cooling water blowdown, while water conservation can minimize net product loss and carryover.

Clearly, some 'process modifications' will occur automatically as a by-product of the continuing improvements which are made in industrial processing and manufacturing methods. In addition, it is generally thought to be virtually impossible to separate process modifications which are brought about by modernization from those which result strictly from a desire to reduce wastes. (Overcash, 1987). However, in the literature which deals with this subject, the term 'process modification' generally refers to modifications which are brought about for waste minimization (recycling/reuse) purposes rather than for other purposes. It is in this context that this term is used in this report.

2.2.6 Housekeeping Practices

Housekeeping practices refer to operational activities such as alteration of manufacturing procedures, employee training and management initiatives which serve to assist in source control of wastes. This categorization, which has also been referred to as " improved operating practices" includes the following elements (Versar and Jacobs, 1986):

- Material handling improvements
- Employee training
- Spill and leak collection and prevention
- Improved scheduling
- Preventative maintenance

- Inventory control
- Segregating waste streams

Examples of practices which would be considered under the term "Housekeeping" include the development and training of employees to ensure that proper operating procedures are used, use of alternate materials or methods which could minimize risk of spillage or waste, segregation of waste streams to facilitate re-use or recycling, and optimized scheduling of batch operations to minimize cleaning frequency.

3.0 FACTORS AFFECTING ONSITE WASTE MANAGEMENT ACTIVITIES

3.1 Overview

There are numerous factors which will affect a company's decision to employ onsite waste management strategies. A significant amount of work has been carried out in the United States in an effort to quantify waste types, identify the key factors affecting reduction, identify and promote waste reduction options and implement appropriate programs and policies which provide regulatory or economic incentives to industry. Policies have been developed both on the Federal and State level, with North Carolina and Massachusetts leading the states in development of waste reduction programs. Because of these efforts, the United States data base is currently more extensive than that still under development in Canada. A review of these activities is therefore considered useful for the purposes of this discussion, and can be used to draw some parallels with anticipated activities in Canada.

One extensive investigation of waste minimization options was undertaken by Versar and Jacobs (1986). They identified the key factors which may affect the implementation of waste reduction strategies. These include:

- Economics and Investment in Technology
- Liability Issues
- Attitudinal Issues
- Consumer Awareness and Public Relations
- Regulatory Requirements

Each of these factors is discussed in more detail in the following sections.

3.1.1 Economic Issues

Until recent years, the most economical and convenient way of handling wastes in many cases has been disposal by landfilling. Environmental concerns and associated regulatory and public pressures are discouraging this practice, and providing incentives to employ alternative waste minimization practices. However, in order to invest in new technology or adapt process modifications, the industry must see a net economic benefit in order to justify implementation.

A variety of economic barriers exist which may make it financially unattractive or difficult for some industries to undertake waste minimization activities. It is difficult to generalize about economic issues since they are very site specific and depend on a variety of factors, such as type of industry, size, and organization of the firm. For example, the capital cost of investment in

alternative technologies or equipment may be prohibitive, especially for smaller companies (McDougall, 1987), however, the extent to which this is true depends greatly on the financial health of the company. Often, if the cost of reducing wastes is more than the cost of disposal or waste management presently incurred by the company, there is little incentive to employ alternative practices. Smaller generators incur some unique problems in addition to constraints in capital outlay, and are more often unaware of techniques and options available to them. In the U.S., some small firms were found that are unable to produce enough waste for offsite haulage and recycling. These firms must therefore store onsite and must obtain the required RCRA approvals and permitting, with their associated cost and inconvenience, in order to do so. To resolve this, some small generators have combined their waste streams in order to make the practices more attractive (Versar and Jacobs, 1986). Investment in innovative technologies by both large and small companies may be discouraging due to the associated risk, availability, adaptability or capital cost of new or emerging technologies.

Economic incentives which are considered to be most effective include the high cost of offsite disposal compared to the cost of onsite waste reduction activitities, the value of recovered products, cost savings incurred in recycling instead of purchasing feedstocks and materials, and the potential benefits of employing newly-developed, more cost-effective technologies which may facilitate recovery and reuse of by products.

3.1.2 Liability Issues

Under regulations in the U.S. and Canada, waste generators are responsible for the treatment, storage and disposal of their wastes, and may therefore be held liable should damages occur as a result of these activities. Because of this, liability insurance has become costly and sometimes difficult to obtain. Offsite recycling may also be considered a risk in situations where there is a fear the recycler could mishandle the wastes, and the generator would be held liable. This combination of factors may serve as an incentive to maximize onsite management of special wastes, in order to minimize the costs and risks associated with insurance and liability claims for offsite hauling, storage or disposal.

3.1.3 Company Attitude/Awareness

Waste reduction activities are also influenced by corporate attitudes and awareness. More stringent government regulations have prompted a re-evaluation of waste management practices by corporate officials in waste generating industries. Lack of awareness of both improved

manufacturing techniques, and new developments in recycling or treatment technologies will act against waste reduction decisions, as will a general resistance to change and fear of adverse effects on production processes or product quality. In the U.S., regulatory requirements are often considered to be a disincentive, since the perception of industry is that many of these requirements are complicated, time-consuming, costly, and may even indirectly restrict recycle or reuse options, such as through limitations in storage approvals which prevent accumulation of sufficient volume to permit recycle (Versar and Jacobs, 1986).

It has been acknowledged that non-regulatory programs which provide technology transfer and further industrial awareness and knowledge of reduction options are key factors in the success of widespread reduction implementation (US Congress, OTA, 1987). This is also demonstrated by the success of the Pollution Prevention Pays (PPP) program in North Carolina (Radian Corporation, 1983). Well informed corporate managers are less likely to harbour misconceptions about policies and technologies, and may therefore be more likely to implement waste minimization practices.

3.1.4 Public Perception

Consumer attitudes and public perception may also influence waste minimization policies. Policies may be affected depending on the extent of public awareness of the environmental effects of manufacturing by-products or processes, and the willingness of the consumer to accept changes in product quality or cost. Companies which actively present themselves as being concerned about the environment and which are implementing waste minimization practices may be better perceived by a concerned public.

3.1.5 Regulatory Issues

Several regulations have been implemented in the United States regarding hazardous waste management. These include the federal Resource Conservation and Recovery Act (RCRA) issued in 1976, and the 1984 Hazardous and Solid Waste Amendments (HSWA) which followed, as well as state and locally administered regulations. These regulations have been shown to act as both incentives and disincentives, both alone and in combination with the factors described above, to the implementation of waste minimization programs. Industries and specialists in the U.S. have mixed reactions to RCRA (Versar and Jacobs, 1986), and identify concerns such as inconsistent implementation across the country, complex requirements, complicated and expensive permitting and approvals, changing requirements and vague deadlines, as disincentives to waste reduction.

The HSWA will significantly affect small businesses in that small quantity waste generators will be burdened with more rigorous requirements than previously. It has been estimated that small and very small businesses in the U.S. constitute 98 percent of all waste generating companies, however, they generate less than 0.5 percent of total wastes annually (Radian, 1986).

Generally, a variety of concerns has been raised in the literature regarding the effectiveness of regulations compared to alternative strategies such as technology transfer and economic incentives in the successful implementation of reduction programs. The Office of Technology Assessment however, considers that despite the noncompliance and complaints expressed by industry, regulation will directly or indirectly affect corporate decisions regarding waste management to some extent (OTA, 1986). Assessments by both OTA and EPA, however, support the use of non-regulatory technical assistance programs to assist industry (OTA, 1987).

The 1984 Amendments to RCRA have been considered to provide substantial incentive, since waste disposal costs became so expensive that companies were essentially forced to consider alternative waste reduction techniques (Anonymous, 1987). An industry survey conducted by the US Congress, Office of Technology Assessment identified the increasing costs of waste management as well as disincentives in land disposal as the two most important factors affecting waste reduction efforts (OTA, 1986). Current waste disposal costs are estimated to be 10 fold greater than ten years ago (Anonymous, 1987). These amendments have imposed a ban on disposing any type of free liquids in landfill sites without prior treatment. This, combined with greater liability for site operators and generators, may be a significant incentive for some generators to reduce their waste quantitites (Overcash, 1986).

Many individual states have typically taken a nonregulatory approach focussing on research grants and technology transfer pertaining to waste reduction. Although the level of effort varies greatly among states, most are focussed primarily on waste management instead of waste reduction. Only North Carolina and Massachusetts have implemented programs specifically directed at waste reduction (Oldenburg and Hirschhorn, 1987). North Carolina has implemented the successful Pollution Prevention Pays (PPP) program, which provides technical support and consultation, as well as a grant system, to individual industries considering waste reduction options.

Government funding programs which support development of technology or innovative solutions, information and technology transfer programs, technical assistance, restrictions or penalties for land disposal, fees and tax incentives, loan assistance, waste exchanges, and grant and award programs, are generally considered to act as the most significant incentives to waste reduction (OTA, 1986). These aspects will be discussed further in Section 4 in the context of the Ontario situation.

3.2 Approach to Data Assessment

Although all of the factors mentioned in Section 3.1 will have some impact on a company's decision to implement one or more onsite waste management strategies, there is concensus in the published literature as to the overall importance of cost as the key factor in the decision making process. (Overcash, 1986; OTA, 1986; Versar and Jacobs, 1986)

Overcash (1986) presents a theoretical relationship between waste reduction and the costs incurred by the Nation's industry to implement waste reduction alternatives. This relationship is an 'S' shaped curve similar to that shown in Figure 3-1. Overcash (1986) reports that "this shape is typical of a number of phenomena which undergo substantial growth but ultimately reach a stage in which further waste elimination is not incrementally cost effective". In the early stages, a minimum cost must be incurred to achieve any waste reduction. Following this, relatively small investments are likely to lead to very substantial levels of waste reduction. Finally, if attempts are made to achieve very high levels of recycle or waste elimination, implementation costs increase substantially. At this stage, the economics of other waste management options such as offsite treatment and/or disposal may become more attractive compared to carrying out further onsite waste minimization steps.

In order to develop a quantitative assessment of the potential for onsite waste management approaches to present the least cost waste management scenario for Ontario industry, it is necessary to derive the numerical relationship between waste reduction and cost for the curve shown in Figure 3-1 and to determine the asymptote for the curve or the maximum degree of waste reduction which can be expected from the implementation of onsite waste management techniques. ZENON's initial approach was therefore aimed at using actual case histories to develop these mathematical expressions for costs (amortized capital plus operating) of various onsite waste management techniques currently in use. Ideally these costs were to be functionally related to the reduction in waste generation achievable by such measures and specific to individual onsite waste management approaches (ie. recycle, reuse, recovery, housekeeping, process modification, etc.) for a range of different industrial sectors.

A review of the literature was undertaken to identify suitable case histories. (Refer to Bibliography and References).

Table B-1 in Appendix B lists twenty-seven of the most promising case histories compiled from a total of one hundred ninety-two reviewed. Cases 1 through 22 inclusive were abstracted from case histories presented by Overcash (1986) while Cases 23 through 27 inclusive were

FIGURE 3-1

Theoretical Relationship Between Waste Reduction and the Costs Incurred by the Nation's Industry to Implement These Alternatives

Source: Overcash (1986)

abstracted from case histories presented originally by Huisingh (1985) and cited by Versar and Jacobs (1986) in their report to the United States Environmental Protection Agency.

The curves shown in Appendix B were fitted to the very limited available data, following as much as possible, the theoretical shape of the curve shown in Figure 3-1. All four curves were plotted as rectangular hyperbolae, passing through the origin and asymptotic to one hundred percent reduction. Rectangular hyperbolae were selected for fitting in this case because they approximate theory most closely and, parameter estimation is easily accomplished by least squares regression.

Figure B-1 illustrates the first generation cost function developed. Three case histories (Nos. 23, 24 and 25) were used to develop Figure B-1. The developed curve represents an aggregated cost function which is not specific to any particular industrial sectors or waste management approaches.

Figure B-2 (Cases 24 and 25), Figure B-3 (Cases 7 and 15) and Figure B-4 (Cases 26 and 27) illustrate the second generation cost functions which apply primarily to manufacturing industries. These curves were developed from case histories which specified the nature of the onsite waste management approach used as either process modification, recycling or housekeeping.

Figure B-5 shows all the above mentioned cost functions in linearized form to facilitate comparisons between curves. As expected, the cost per tonne for any given percentage reduction is seen to be highest for the process modification approach, while recycling exhibits a lower cost function and housekeeping exhibits one even lower. Somewhat surprising is the substantial apparent difference between the cost function for process modification and the cost functions for recycling and housekeeping. Little difference between the latter two cost functions appears to exist as evidenced by the similarity between respective parameter values (0.04 and 0.01). The composite cost function approximates the middle ground between the process modification and housekeeping approaches.

3.3 Status of Economic Data

Although a considerable effort was given to correlating available data on the costs of various onsite waste minimization approaches from the literature as outlined in Appendix B, this assessment failed to yield sufficient data for carrying out meaningful qualitative economic assessments of any of these alternative approaches (ie. cost vs. % reduction). The cost curves presented in Appendix B are not appropriate for this purpose. This information has been included simply to identify the approach taken and demonstrate the inadequacy of the available data.

Unfortunately case histories which span a useful number of industrial sectors and have all the required details on cost-effectiveness are not available. With only one exception (Case 27), all of

the tabulated cases fall into eight major groups within a single division (Division E - Manufacturing Industries) of the Canadian Standard Industrial Classification Code. The lone exception falls into Division H (Communication and Other Utility Industries). Only seven cases (7, 15, 23, 24, 25, 26 and 27) of the twenty-seven tabulated cases included sufficient information to formulate the required relationship between cost per tonne and percentage reduction. In the remaining cases, waste reduction was reported per unit of finished product but, unfortunately, a cost per tonne could not be determined since the quantity produced was not given.

In addition, the developed cost functions do not apply to the reduction of all waste streams generated at a given plant. Rather, they reflect very specific waste reduction successes and therefore properly apply only to single waste streams which likely represent only part of total plant wastes. It is for this reason that the complete reduction of wastes (ie. one hundred percent) appears possible when any one or combination of the three waste minimization approaches is applied. In practice, however, it is not possible to achieve levels of onsite waste reduction of 100% unless massive economic committments are made to reuse all materials (Overcash, 1986). The actual maximum levels of reduction which are cost-effective are in fact considerably less than 100%. These aspects are discussed further in the following section.

3.4 Estimated Waste Reductions Achievable by Onsite Waste Minimization Techniques

Although it is not possible to assign costs to the theoretical curve shown in Figure 3-1 because of a lack of data, information has been assembled in recent years which provides some insight into the estimated waste reductions which are likely to be achievable by industry through the use of onsite waste minimization techniques. In February and March of 1986 the Office of Technology Assessment in the US (OTA, 1986) conducted a survey of industry personnel which asked questions about how and why waste related decisions are made. Responses were received from a cross section of large and small industries representing eleven different Standard Industrial Classifications (SIC's) from more than 20 states in the US. When respondents were asked "Using best available technology in 1980, how much hazardous waste (all types in all types of environmental media) generated by your operation in 1980 could have been avoided?", the responses were as follows:

59% responded less than 25% reduction
30% responded 25 to 50% reduction
11% responded 50 to 75% reduction

When asked the same question using best available technology in 1985, the responses shifted slightly upward with 15% responding 50 to 75% reduction possible (OTA, 1986). The median value of this data corresponds to a reduction of between 20 and 25% overall. This is consistent with the work of Versar and Jacobs, (1986) which suggests a future achievable waste reduction of 28% across a range of chemical and allied industries. This is also consistent with similar information which was developed by Battelle, (1985) and used by Radian, (1985) in their assessment of the effects of waste minimization on the quantities of hazardous wastes expected to require treatment and disposal in the state of North Carolina. The waste minimization factors which were developed by Battelle indicate that for wastes which would normally go to incineration, landfilling and physical/chemical treatment, the estimated percentage reductions which can be expected to be achieved by waste minimization programs are as follows:

For wastes which are incinerated	25% reduction
For wastes which are landfilled	30% reduction
For waste which given physical/chemical treatment	15% reduction

These data, along with confirming discussions with Overcash, (1987) indicate that all onsite waste minimization options, when taken together across a range of industrial sectors, are likely to result in an estimated overall reduction in hazardous waste generation of approximately 20 to 30%; recognizing, of course, that higher (or lower) reductions could be achieved on specific waste streams in specific industries.

It is important to emphasize at this point that these overall estimates of reduction potential include the combined effects of both source reduction activities and onsite treatment activities in terms of their potential for minimizing wastes which require offsite treatment and/or disposal. Battelle (1985) in their study indicate that: "Many recovery/recycling technologies generally employ modifications of physical/chemical, biological or incineration technologies to recover or reuse a valuable waste ingredient or by-product that otherwise would be destined for hazardous waste treatment and disposal". Battelle cites several examples of successful waste reduction and/or recovery/recycling techniques including: distillation, vacuum evaporation, reverse osmosis, ion exchange, sludge dewatering, waste oil re-refining, direct reuse of waste acids e.g. spent pickle liquors, process substitutions and waste segregation. The OTA (1986) have also stated that the definitions used by States and in studies generally include "all waste recycling or waste treatment or both". As indicated previously in this report (p.6), it is not possible given the available information, to separate the relative contributions of source reduction vs. onsite treatment in achieving the expected overall waste reduction potential indicated above. The OTA have identified this confusion in terminology as a major problem which, if left unresolved by government will

divert attention away from the more desireable goal of enhancing true waste reduction rather than simply improving 'waste management' practices in general.

A review was made of the projected waste reduction information presented in the New Jersey hazardous Waste Facilities Plan (March 1985) prepared by Environmental Resources management Inc. (ERM). For purposes of comparison, we have also investigated the rationale behind the development of similar information contained in the Final Report on Hazardous Waste in North Carolina (February 1985) prepared by Battelle Columnbus Laboratories and adopted for use in a subsequent study for that State (December 1985) by Radian Corporation. The waste reduction factors for New Jersey reported by ERM were established by engineering judgment using information from the following sources:

- The New Jersey Industrial Waste Survey prepared by IT Enviroscience, in cooperation with the Research and Development Council of New Jersey, which asked questions regarding generators' future plans.

- Extensive surveys and analysis conducted by the Minnesota Waste Mangement board of wastes that are similar in many ways to New Jersey wastes. The goal of the Minnesota study was to understand the opportunity for practicable wastes reduction.

- General experience with numerous generators of hazardous waste as part of the other projects.

In general, the reported waste reduction factors were estimated from: i) an analysis of expected future changes to 1988 as suggested by the New Jersey Research and Development Council survey, (ii) a correlation of these findings with similar studies, such as that carried out by the State of Minnesota and (iii) verifying the resulting estimates against general experience and New Jersey generators' past and present attempts at waste reduction.

The waste reduction factors to 1990 for North Carolina reported by Battelle (i.e. 25% reduction of incinerables; 30% reduction of landfillables; 15% reduction of physiocochemical treatables) where also established by engineering judgment. The baseline information for this purpose was obtained through telephone interviews with eighteen industrial waste generators and with two waste management officials from the state of North Carolina. The waste generators were asked to provide estimates of the future effects their waste reduction activities would have on the type and quantities of wastes they would be sending offsite. The waste management officials were asked to estimate the effect of the implementation of various waste reduction techniques on the amounts of hazardous wastes that would be designated by industry for offsite management.

The eighteen North Carolina waste generators indicated that they expected waste reductions for incinerables, landfillables and physiocochemical treatables to be 51%, 61% and 15% respectively. The two state officials indicated an expected reduction of only 10% for each of the three categories. In Battelles' judgement, respective waste reduction factors of 25%, 30% and 15% appeared more appropriate because they felt that industry was being overly optimistic and the State officials overly pessimistic in their estimates. Battelle's estimates also account for non-random sampling in the selection of industrial respondents as well as the obvious skew toward large waste stream generators. It is emphasized that Radian Corporation accepted Battelles' judgement on this aspect; accepting Battelles' estimates for subsequent use.

ZENON's simple re-tabulation of the New Jersey waste reduction factors is presented in the accompanying Table 3-1 and facilitates comparison with those of Battelle for the North Carolina situation as shown in Table 3-2 below. The re-tabulated factors suggest average expected waste reductions of 24%, 14% and 25% for incinerables, landfillables and physicochemical treatables in the State of New Jersey.

TABLE 3-2

Expected Waste Reduction Factors

	New Jersey	North Carolina
Incinerables	24%	25%
Landfillables	14%	30%
Physiocochemical Treatables	25%	15%

Table 3-2 shows that there is no difference in the two estimates for the expected reduction in incinerable wastes and that there is somewhat compensating disparity between the two estimates of reduction in landfillables and physicochemical treatables. When viewed in totality, there appears to be general agreement between the estimates, considering the expected error for each.

The implication of this comparison is that the information presented in Table 3-1 is substantially corroborated. Moreover, it is considered that the figures are consistant with those we have seen and reported earlier from other sources.

3.4.1 Applicability to the Ontario Situation

In order to validate the applicability to the Ontario situation of the waste minimization estimates derived from data relating to other geographical areas, a comparison of respective

TABLE 3-1

SUMMARY OF EXPECTED PERCENTAGES OF WASTE REDUCTION BY INDUSTRY CLASS AND WASTE TYPE

WASTE DESCRIPTION	OWMC CLASS	SUITABLE TREATMENT	US/Cdn SIC CODE											
			281	282	285	286	287	289	29	33	34	35	36	
			371	371&373	375	371&379	372	371&379	27&36	29&30	30, 32, 37	30 ,31, 32, 33	32, 33, 39	US SIC CND SIC
Aqueous Organic	9			30										
Solvents (non halogenated)	2				50									
Solvents (nos)	2				50						25			
Oils (automobile)	3	incineration									25			
Oils (industrial)	3									10				
Oils (fuel)	3									10	10	25		
Oils (nos)	3									10				
Sludges and solids (paint)	8				50					10				
Sludges and solids (organic)	1				50	-20								
														}Average Reduction ~24%
Sludges and solids (heavy metals)	6	landfilling	-10			50			-10					
Other	7		-10			50								}Average Reduction ~14%
Aqueous (inorganic)	6	physiochenical	20	10		20	20	20	50	30	30	30	30	
Other Liquids (corrosive)	9										10			}Average Reduction ~25%

(nos) - not otherwise specified
All values are in %

Source: EMR Inc. 1985, New Jersey Hazardous Waste Facilities Plan. Prepared for New Jersey Hazardous Waste Facilities Siting Commission, March 1985.

industrial bases was undertaken. The approach to comparison involved a consideration of two aspects for each geographical area. The first aspect involved an assessment of the breadth of industrial base. The measure used for this assessment was the number of industrial sectors which generating special wastes. The second aspect involved an assessment of the relative size of each sector within each industrial base. The percentage of the total waste generated by each sector in a given area was the measure used for this purpose. This assessment was aimed at identifying any major differences in industrial activity and waste types within each sector which would tend to invalidate our conclusion that waste reduction which are expected to be achievable overall by onsite waste minimization techniques in Ontario can be expected to be reasonably consistent with those estimates which have been made for New Jersey and North Carolina (i.e. 20-30% overall for all industries and all waste minimization approaches).

Four data bases were included in the comparison. These contained waste generation information, partitioned by industrial sector, from the following sources:

- North Carolina 1986 Report of Hazardous Waste
- New Jersey Hazardous Waste Facilities Plan, Environmental Resources Management Inc., (1985).
- Ontario (Regulation 309) Generator Data (1987)
- Ontario 1000 Industry Survey, Canviro Consultants Ltd. (1985).

The information from all four data bases is summarized in Table 3-3 and Figure 3-2.

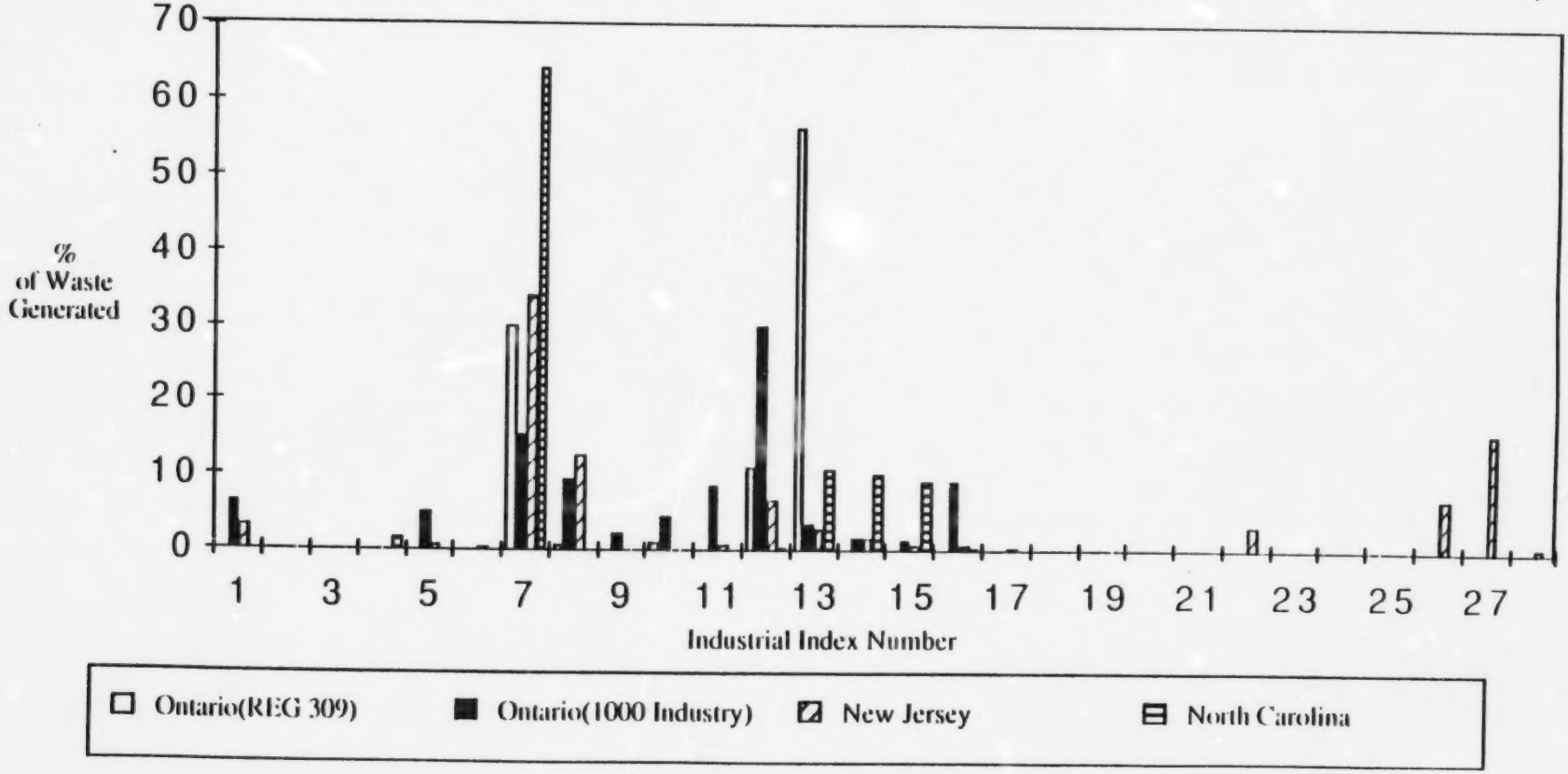
Table 3-3 reveals that twenty-eight industrial sectors from the basis of the comparison. In the case of North Carolina, twenty-one sectors (75%) generate 98% of the special waste. A similar situation exists in the case of New Jersey, where twenty-one sectors generate 95% of the special waste. With respect to Ontario, the Regulation 309 Generator Data indicates that only nine sectors (32%) account for 100% of the registerable waste in the province. In contrast, the Ontario 1000 Industry Survey suggests that eighteen sectors (64%) generate 100% of the special waste. These results indicate dissimilarity between the Ontario results but this dissimilarity may have arisen from fundamental differences in data gathering techniques between the two databases. Table 3-3 also suggests that there is some dissimilarity between the breadth of industrial waste generation in Ontario compared to North Carolina and New Jersey. This is expected. In this case the degree of difference depends on which of the two Ontario databases is used as reference.

Figure 3-2 illustrates that there is a pattern of similarity in the relationship between industrial sector and proportion of special waste generated in all three geographical areas. In general, industrial sectors which generate a high proportion of wastes are similar within each area. There are disparities in the proportions within sectors, particularly in those corresponding to the chemicals

TABLE 3-3
INDUSTRY COMPARISON (ONTARIO - NEW JERSEY - NORTH CAROLINA)

INDUSTRIAL INDEX NUMBER	US SIC CODE	DESCRIPTION	PERCENTAGE of WASTE GENERATED in GIVEN INDUSTRIAL SECTOR			
			ONTARIO CANVIRO 1000 INDUSTRY SURVEY	ONTARIO REG 309 GENERATOR DATA [1987]	NEW JERSEY ERM INC. PROJECTED FOR 1983	NORTH CAROLINA 1986 REPORT OF HAZARDOUS WASTE
1	20	Food and kindred products	6.4		3.5	
2	22	Textile mill products	0.2		0.2	0.02
3	24	Lumber and wood products	0.1			0.18
4	25	Furniture and fixtures	0.2		0.1	1.73
5	26	Paper products	5.3	0.0031	1.0	0.04
6	27	Printing and publishing	0.2	0.00155	0.4	0.1
7	28	Chemicals	15.8	30.07	34.1	64.31
8	29	Petroleum	9.7	0.98	12.8	0.02
9	30	Rubber and plastics	2.5		0.2	0.03
10	31	Leather products	4.5	1.04	0.1	
11	32	Stone, clay, glass and concrete products	8.7		1	0.05
12	33	Primary metal industries	30.0	11.09	6.8	0.54
13	34	Fabricated metal products	3.8	56.44	3.2	10.9
14	35	Machinery, except electrical	1.9		1.7	10.37
15	36	Electrical and electronic machinery	1.4		0.7	9.41
16	37	Transportation equipment	9.4		1	0.38
17	38	Measuring, analyzing and controlling instruments	0.1		0.6	0.03
18	39	Miscellaneous manufacturing industries	0.3			0.04
19	42	Motor freight transportarion and warehousing			0.3	
20	45	Transportation by air				0.02
21	46	Pipeline, except gas				0.06
22	49	Electric, gas and sanitary services			3.5	
23	50	Wholesale trade, durable goods				0.08
24	51	Wholesale trade, nondurable goods				0.02
25	55	Auto dealers and gasoline stations		0.19		
26	73	Business services		0.06	7.1	
27	76	Miscellaneous			15.9	
28	90-97	Government and military			0.7	0.14

Figure 3-2 **INDUSTRY COMPARISON** (Ontario - New Jersey - North Carolina)



(Index 7), petroleum (Index 8), primary metals (Index 12) and fabriacated metal products (Index 13) industries respectively. These disparities represent aactual geographical differences in industry. However, these disparities represent actual geographical differences in industry.

Overall, we feel it is reasonable to conclude from this comparison that we are not dealing with order of magnitude differences in the types of industries and wastes present in the three areas being compared. In other words, we are not trying to compare a Province which contains a reasonably wide range of industry types and sizes to States which are largely rural and/or agricultural in nature or vice versa. As such, we feel that in the absence of any better data which more specific to the Ontario situation, that it is reasonable to conclude that the estimated percentage reduction figures of 20 to 30% which have been cited for New Jersey and North Carolina are expected to be applicable to the Ontario situation over the medium to long term.

4.0 IMPACT OF CURRENT AND PROJECTED GOVERNMENT PROGRAMS

4.1 Current and Projected Waste Reduction Programs for Ontario Industries

The Province of Ontario is now well into the process of developing and implementing more stringent hazardous waste regulations. There are various regulations and programs under development in Canada, some of which have been modelled after U.S. experience. The following sections discuss these programs in the context of the influence such programs are likely to have on the extent and timing of onsite waste management activities in Ontario.

4.1.1 Federal Regulations and Programs

Regulations

In contrast to the U.S. where RCRA is a federally administered hazardous waste regulation, hazardous waste management in Canada is primarily under the jurisdiction of the provincial governments. No federal government regulations were identified which could be expected to have a substantial direct or indirect impact on waste reduction activities.

Programs

Environment Canada is administering several funding programs intended to increase waste reduction in Canada, They include the following:

- Development and Demonstration of Resource and Energy Conservation Technology (DRECT)
- Industrial Research Assistance Program (IRAP)
- Waste Oil Recovery Program
- Silver Recovery Program
- Canadian Waste Materials Exchange

Due to restructuring within the Department of the Environment and increased emphasis on provincial legislation, Environment Canada's role is expected to be primarily technology and information transfer and research and development.

4.1.2 Provincial Regulations and Programs

Regulations

The provinces are in the process of developing and administering an extensive regulatory framework for the managment of hazardous waste. In Ontario, Regulation 309 was amended in

1986 and this has resulted in substantial activity because of the exemptions allowed to some generators who practice recycling. The regulation also required auditing of waste streams, provided more clearly defined hazardous waste classifications, and has resulted in the implementation of an expanded Waste Manifest system for transportation and disposal of wastes, and more extensive generator registration. This combination of factors have successfully served as initiatives to some industries to identify and/or implement improved practices, and improvements in recycling activity have already been indicated (Breeze, 1987).

Bill 308, currently under development, provides regulations on air emissions in the Province of Ontario. Although the regulation is currently being formulated, it is anticipated that more clearly defined and more stringent requirements on industrial air emissions will be imposed. The relatively small amount of contaminants recovered from air emissions can be expected to account for a slight increase in hazardous wastes requiring offsite disposal (Breeze, 1987).

The Municipal and Industrial Strategy for Abatement (MISA) program, administered by the Ontario Ministry of the Environment, is directed toward the eventual promulgation and enforcement of effluent regulations for major industrial sectors. Pre-regulation monitoring programs are now being carried out for each sector and these will be followed by a monitoring regulation stipulating the long-term requirements for effluent characterization. The results obtained will be used to develop maximum discharge criteria based on identification of Best Available Technologies (BAT) for treatment of each waste type. Since municipal sewage treatment plants are considered as the municipal "sector", they too will ultimately be required to meet pre-defined discharge criteria. This will in turn likely lead to increased pressure towards pre-treatment of industrial effluents prior to sewer discharge, since municipalities will likely discourage the acceptance of highly contaminated wastes through prohibitively high sewer discharge fees, or refusal to accept certain waste types. It is anticipated that the MISA program will encourage onsite waste reduction practices, through the imposition of effluent regulations for industries directly discharging to water bodies, as well as through indirect pressure to adopt end-of-pipe treatment and reduction or recycling practices.

Programs

At the present time, the Ministry of the Environment is in the process of reassessing the long-term strategy for hazardous waste management in the Province of Ontario. Major initiatives as outlined in the "Blueprint for Waste Managment in Ontario", prepared in 1983, have now been addressed and the future directions are now being developed. Recently, a meeting/workshop sponsored by the MOE and organized by the Canadian Environmental Law Research Foundation (CELRF) was held involving about 40 representatives from industrial, government, legal, and private interest groups to debate and resolve a variety of regulatory and non-regulatory issues in

future hazardous waste managment and the 4R's (EcoLog Week, 1987a). Concensus was reached regarding the need for adequate information and technology transfer programs, and it was agreed that economic barriers such as sales tax currently imposed on recycled oils should be removed. There was mixed opinion on the effectiveness of regulating the levels of recycling, and the practicality of setting 4R's targets. For this reason, consideration was given to the current and proposed regulations and amendments, such as further expansion of the recycleable materials exemption. It is expected that a discussion paper summarizing the results of the workshop will be available for review in November.

The Ontario Ministry of the Environment also established a special unit in 1986 in the Waste Management Branch to encourage industrial recycle, recovery, reclaimation and reuse (4R's), to coordinate the transfer of technology and information and provide financial support of recycling technology development and demonstration. A Comprehensive Funding Program was recently announced by the MOE to assist in waste managment. It will increase financial support for two existing programs, Waste Management Improvement Program, and the Waste Management Master Plan Program, and will initiate three new programs, for a total of $8.5 million in funding support. (EcoLog Week, 1987b) Of these, two mechanisms can be considered as initiatives in onsite waste reduction, although the majority of funding will be directed at municipalities, and a small percentage will be directed at hazardous wastes. The Municipal Material Recovery Program will provide partial or complete grants for eligible projects involving the development of processes and facilities for recovery and reuse of products from municipal wastes. The Municipal Reduction and Re-Use Program, announced concurrently, will support municipal initiatives and consumer awareness of reduction options.

The Ontario Waste Management Corporation also has its own program designed primarily to promote the reduction of industrial wastes at source. Its mandate is to initiate, stimulate and encourage the recycling, reduction, recovery and exchange of liquid industrial and hazardous wastes in Ontario. This is achieved by providing information and technology transfer assistance to industry, assisting the Ontario Waste Exchange, assisting industry in carrying out characterizations of complex industrial wastes, providing in plant technical assistance on specific waste management problems and, providing funding for minor research and development work.

A review of other waste reduction initiatives undertaken by both the federal and provincial governments is provided in the Hazardous Waste Management Handbook, Fourth Edition (Glen and Orchard, Eds, 1986).

4.1.3 Federal and Provincial Waste Exchanges

The Canadian Waste Materials Exchange (CWME) was established in 1978 to facilitate the reuse and recycling of industrial waste. The Exchange receives funding support from federal and provincial governments as well as private industry, and operates and coordinates a country wide network of waste exchange opportunities. Hundreds of companies are registered with the Exchange, and it is estimated that about one in five find interested customers, although the only payment involved is typically the cost of transportation (McDougall, 1987). To augment the CWME, provincial exchanges have been set up in Ontario, Alberta, and Manitoba.

4.1.4 Summary

As indicated previously in Section 3.1.5, government funding programs which support development of technologies and innovative solutions, information and technology transfer programs, restrictions or penalties for land disposal, fees and tax incentives, loan assistance, waste exchanges, etc. are considered to act as real incentives for industries to become involved in waste reduction activities (OTA, 1986). The fact that some of these programs, such as the Comprehensive Funding Program, MOE 4R's, OWMC 4R's, Ontario and Canadian Waste Exchanges and generator registration are still in their early stages of development in Ontario, means that their influence has still to be felt.

The North Carolina experience provides an indication of the lag time which could be experienced in Ontario until the impact of such programs is likely to be felt with respect to onsite waste management. In North Carolina, generator registration has been given a very high profile in the state since that time through the Pollution Prevention Pays (PPP) program, government grant programs, etc. In spite of this, according to Overcash (1987), it has only been in the past two years that any decrease in waste generation rates in the state could possibly be attributed, even in part, to the waste minimization measures which have been adopted. Even this judgement is very subjective since the collection of waste quantity data in the state is not set up to detect the influence of such measures. On this basis, it is concluded that the impact of the measures which are in place in Ontario at the present time will not likely be felt in terms of their impact on the implementation of onsite waste minimization efforts for perhaps 5 years or more, and unless steps are taken now to collect the appropriate data they may never be quantifiable.

5.0 CONCLUSIONS

The following points summarize the overall conclusions which can be drawn from the assessments completed to date in determining the current and future prospects for onsite special waste management in Ontario:

- Economics play a key role in a company's decision to implement onsite waste minimization approaches.
- The relationship between onsite waste reduction and cost can reasonably be expected to follow an 'S' shaped curve similar to that shown in Figure 3-1.
- The available data indicates that, when the potential combined effects of all waste minimization approaches are considered across the complete range of industrial sectors, the overall percentage waste reduction which can be expected to be achieved onsite by waste minimization measures is in the order of 20 - 30%. The available data also suggests that this average percentage waste reduction value can range from 15 to 75% from plant to plant and from 0 to 100% when specific waste streams are considered.
- The total amount of waste generation that can be avoided by onsite waste minimization measures is not well known because of difficulties in obtaining reliable data (National Academy of Science, 1985).
- Sufficient data are not available to enable cost values to be assigned to Figure 3-1.
- Most waste reduction efforts in US industry are still in their early stages (National Academy of Sciences, 1985). This is also true in states such as North Carolina which have generally had a much higher awareness of these issues compared to other states due to government involvement in waste minimization programs (Overcash, 1987). In view of the fact that generator registration, 4R's programs and government incentives have only just been started in Ontario, it is reasonable to conclude that Ontario, too, is in the very early stages of waste minimization.
- Collectively, MISA and the 4R's programs which are currently in place in Ontario appear to provide a majority of the key factors which are expected to create positive incentives for industries in Ontario to expand their waste reduction activities. On this basis, there is every reason to believe that over time, Ontario will be capable of similar overall percentages of waste reduction to those cited for other jurisdictions in the U.S. (i.e. 20 - 30%).

- At the current stage of development of industrial waste management programs across the US, substantial progress in reducing the amount of hazardous waste generated can be achieved by employing relatively simple methods that involve relatively modest capital expense. Such methods are expected to emphasize engineering or plant specific circumstances (National Academy of Science, 1985). Because Ontario would appear to be at best at a par with the US, this pattern of progress can also be expected to occur in Ontario.
- The time scale of development of these activities since the introduction of generator registration in North Carolina in 1980 would suggest that it could be five years or more before the effects of government and industry waste minimization programs are seen in terms of reduced quantities of hazardous wastes generated. In addition, such reductions may be difficult or impossible to measure due to the difficulties in obtaining reliable data.
- An important impediment to implementing low cost waste reduction practices is lack of access to information about them. Developing means to exchange and disseminate information about successful waste reduction projects is an essential first step toward reducing future waste reduction (National Academy of Science, 1985). This step has already been taken in Ontario with the formation of the MOE and OWMC 4R's programs.

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APPENDIX A

SCOPE OF WORK

Assess Current and Future Prospects for Onsite Special Waste Management

Purpose:

- Establish current and possible future role and activity of the onsite waste management in Ontario.

Approach:

- Review OWMC work to date, including MIR.
- Identify waste types and quantities currently treated onsite.
- Identify range of approaches and technologies used; include:
  - Housekeeping
  - Process Change
  - Internal Recycling
  - Onsite Treatment
  - Onsite Disposal
  - Onsite Storage
- Document regulatory process applicable to the sector:
  - Identify pertinent regulations
  - Specify how the regulations affect activity, with special reference to adopting new technologies
- Identify and evaluate pertinent economic factors:
  - Capital costs
  - Costs of obtaining approvals
  - Operating costs
  - Other
- Assess constraints to current and future capacity expansion:
  - Regulatory
  - Economic
  - Other
- Review and assess impact of current and projected government and other programs available to assist onsite management:
  - MOE
  - OWMC
- Assess likely future role in Ontario under a range of plausible assumptions future regulatory and economic environment. Include an assessment of the relevance of US experience since RCRA to the future Ontario setting.

APPENDIX B

CASE HISTORIES

Table B-1

Compilation of Special Waste Management Case Histories

Reference	Company	Location	Canadian SIC Code			Product	Description of Waste Management Accomplishment	Primary Waste Management Approach			Year	Waste Reduction		Total Cost	Cost per Tonne
			Division	Group	Class			Recycle	Changes	Housekeeping		Quantity	Percent	$$	$$
1	NA	France	E	29	299	Treated wood	Process addition for gaseous & liquid discharge reduction		1		NA	2 m3/t	20	1045	
1	NA	France	E	37	371	Ammonia	Incorporation of hydrogen recovery system	1			NA	3.27 kg/t	99	24690	
1	NA	France	E	37	371	Hydrazine Hydrate	Incorporation of new process		1		NA	27 m3/t	100	12936	
1	Chlor-Chlore	St. Auban, France	E	37	371	NA	Improved recovery of hydrochloric acid	1			NA	66.5 m3/t	98	9240	
1	NA	France	E	37	371	Ethyl-benzene	Recovery of product	1			NA	1.5 m3/t	100	2375	
1	NA	France	E	37	371	Ester	Catalyst change and heat exchanger improvement		1		NA	0.7 m3/t	100	14881	
1	NA	France	E	37	376	Detergent	Effluent recycle	1			NA	1410 kg/hr	85	4007	8.1
1	NA	France	E	29	291	Etched steel	Sludge reduction and metal recovery	1			NA	11.1 m3/t	33	39179	
1	NA	France	E	29	291	Etched steel	Incorporation of a new, dry process		1		NA	0.18 m3/t	100	850	
1	NA	France	E	29	291	Etched steel	Improved recovery and recycle	1			NA	46.25 m3/t	86	19403	
1	NA	France	E	29	299	Treated brass pieces	Solvent substitution		1		NA	38 m3/t	95	490	
1	NA	France	E	30	305	Wire	Incorporation of a new, dry process		1		NA	50 kg/t	91	920	
1	NA	France	E	29	299	Lead plates	Process modification		1		NA	78 m3 /1000 plates	98	2587	

ociation of Special Waste Management Case Histories

Case No.	Reference	Company	Location	Canadian SIC Code			Product	Description of Waste Management Accomplishment	Primary Waste Management Approach			Year	Waste Reduction		Total Cost	Cost per Tonne
				Division	Group	Class			Recycle	Changes	Housekeeping		Quantity	Percent	$	$
25	2	Emerson Electric Co.	Murphy, N.C.	E	33	332	Finished metal	Equipment installation for waste reduction and elimination		1		NA	21 t/yr	100	5525	263.1
26	2	Data General Corp.	Clayton, N.C.	E	33	335	Printed circuit boards	Process changes to obtain marketable copper sludge			1	1981	364 t/yr	100	316	0.9
27	2	Duke Power Co.	Charlotte, N.C.	H	49	491	Electric power	Establishment of an on going waste minimization program			1	1979	31364 t/yr	95	8650	0.3

Reference 1. Overcash, M.R. (1986). Techniques for Industrial Pollution Prevention, A Compendium for Hazardous and Nonhazardous Waste Minimization, Lewis Publishers Inc., Chelsea, Michigan

Reference 2. Hutsingh, D. et al. (1985). Proven Profit from Pollution Prevention, Institute for Local Self-Reliance, Washington, D.C.

Figure B-1

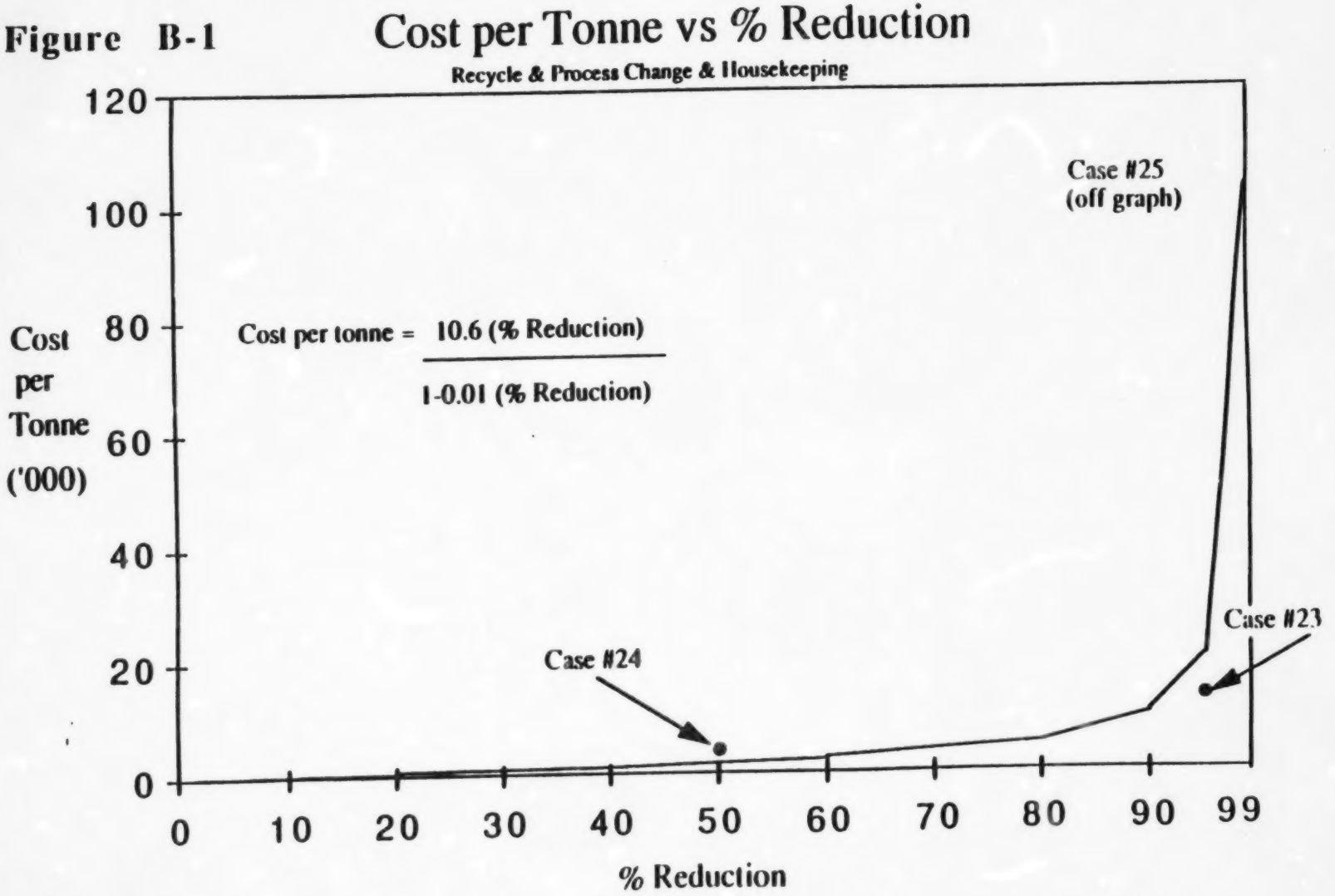
Cost per Tonne vs % Reduction
Recycle & Process Change & Housekeeping
Cost per Tonne ('000)
120
100
80
60
40
20
0
Cost per tonne = 10.6 (% Reduction) / 1-0.01 (% Reduction)
Case #25 (off graph)
Case #23
Case #24
0
10
20
30
40
50
60
70
80
90
99
% Reduction

Figure B-2

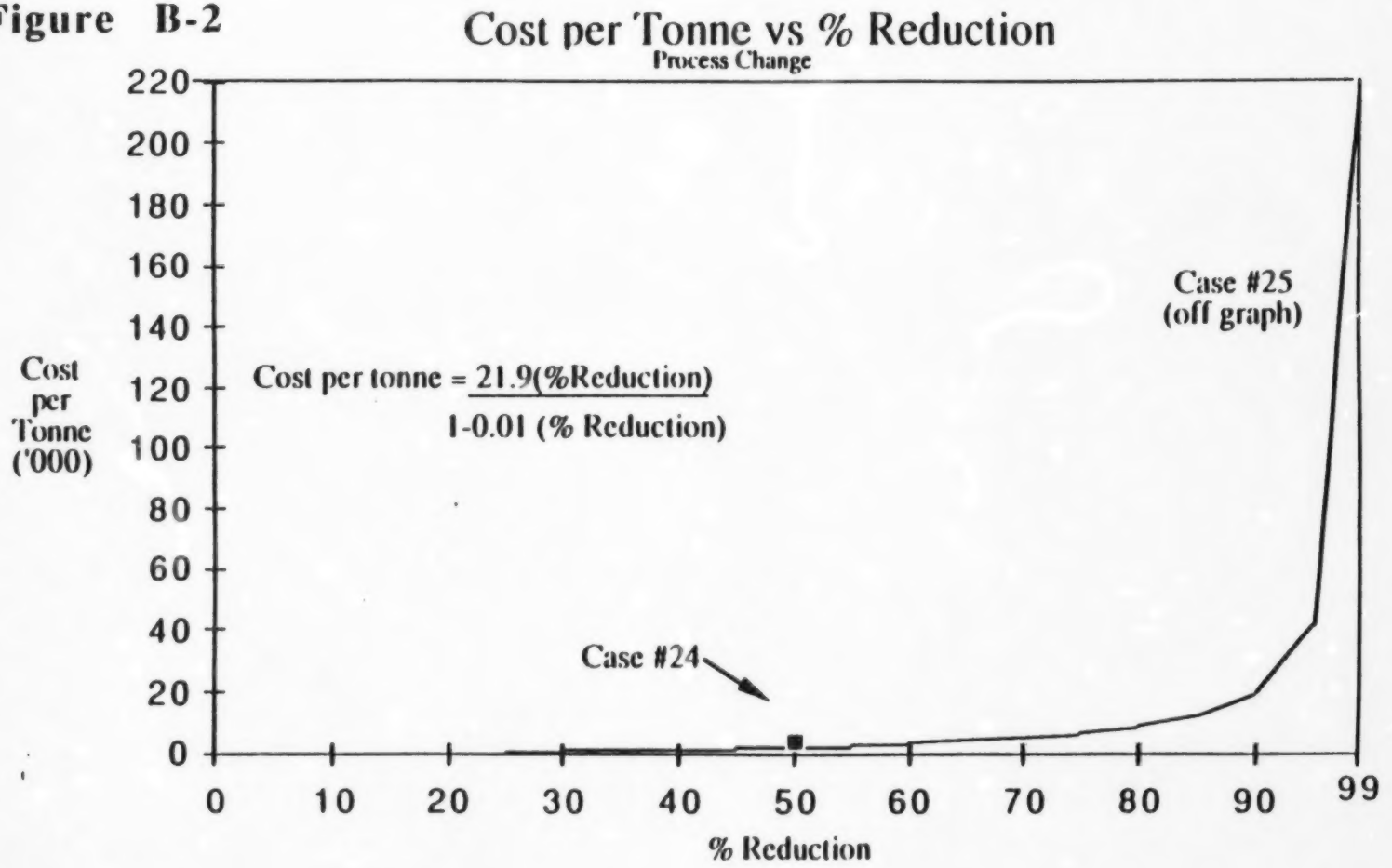
Cost per Tonne vs % Reduction
Process Change
Cost per Tonne ('000)
220
200
180
160
140
120
100
80
60
40
20
0
Cost per tonne = 21.9(%Reduction) / 1-0.01 (% Reduction)
Case #25 (off graph)
Case #24
0
10
20
30
40
50
60
70
80
90
99
% Reduction

Figure B-3

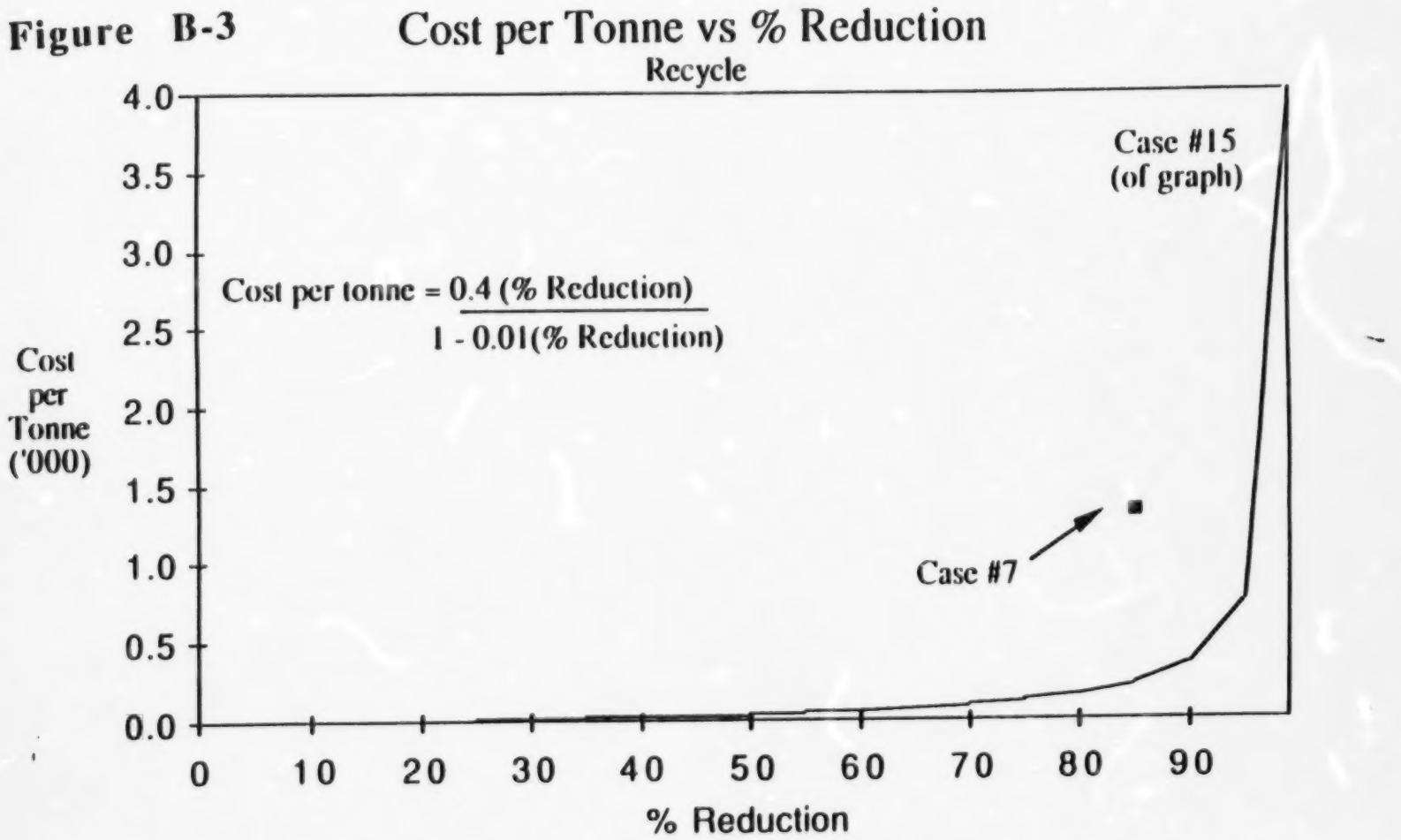
Cost per Tonne vs % Reduction
Recycle
Case #15
(of graph)
Cost per tonne = 0.4 (% Reduction)
1 - 0.01(% Reduction)
Case #7
Cost per Tonne ('000)
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0
10
20
30
40
50
60
70
80
90
% Reduction

Figure B-5 Linearized Cost vs % Reduction Curves
For Specific Techniques & Composite

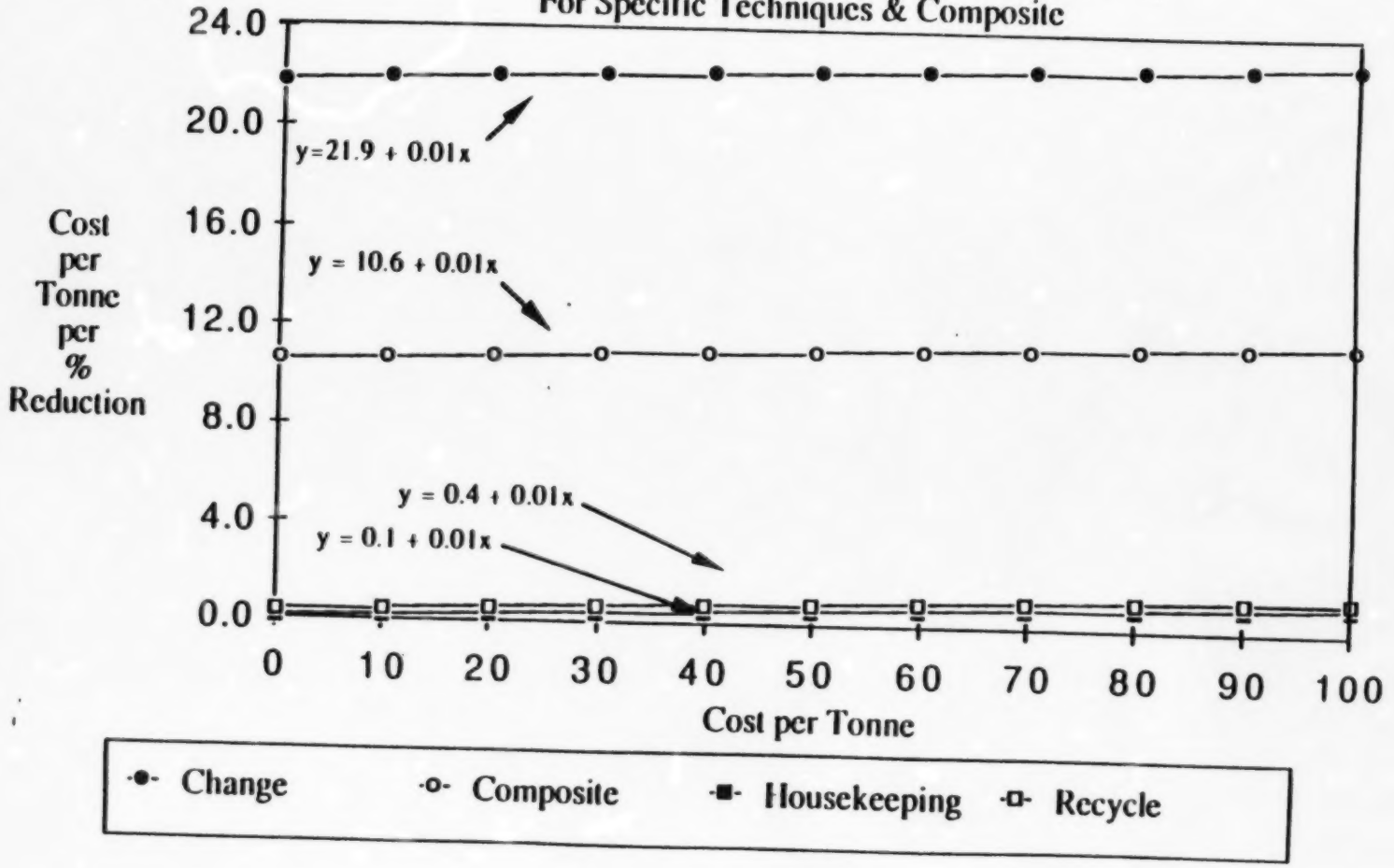

Figure B-2

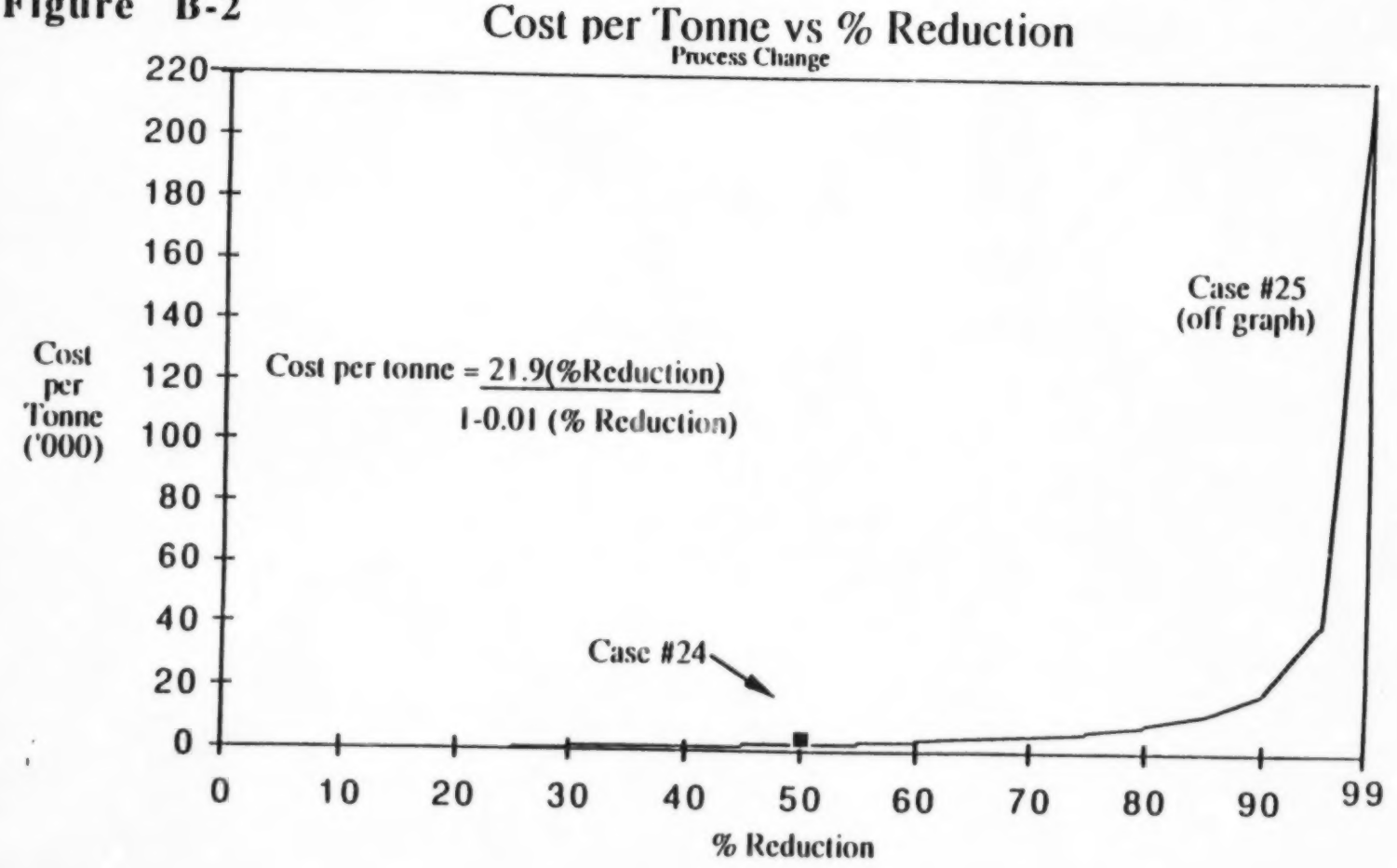
Cost per Tonne vs % Reduction
Process Change
Cost per Tonne ('000)
220
200
180
160
140
120
100
80
60
40
20
0
Cost per tonne = 21.9(%Reduction)
1-0.01 (% Reduction)
Case #25
(off graph)
Case #24
0
10
20
30
40
50
60
70
80
90
99
% Reduction

Figure B-3 Cost per Tonne vs % Reduction

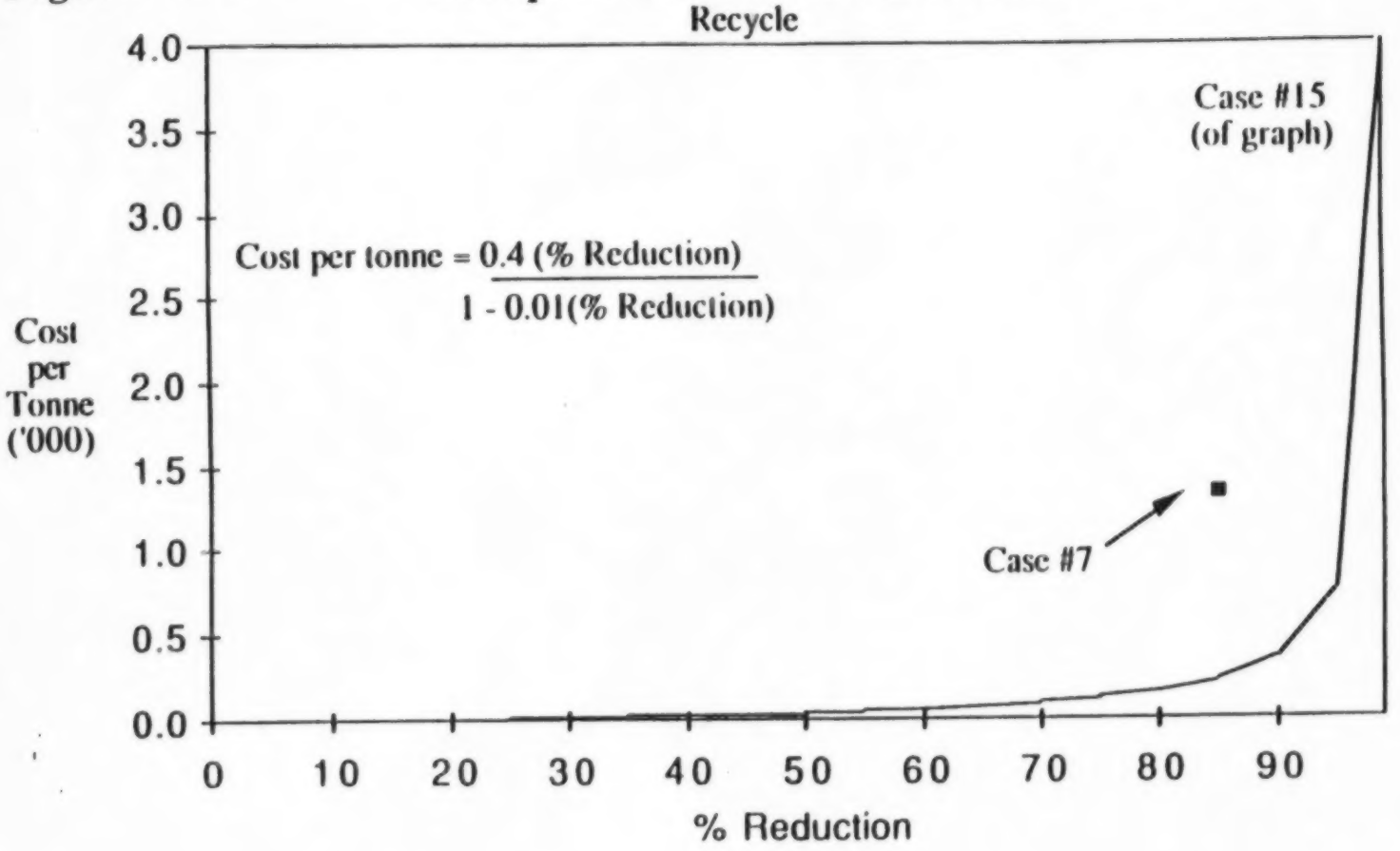

Figure B-4 Cost per Tonne vs % Reduction

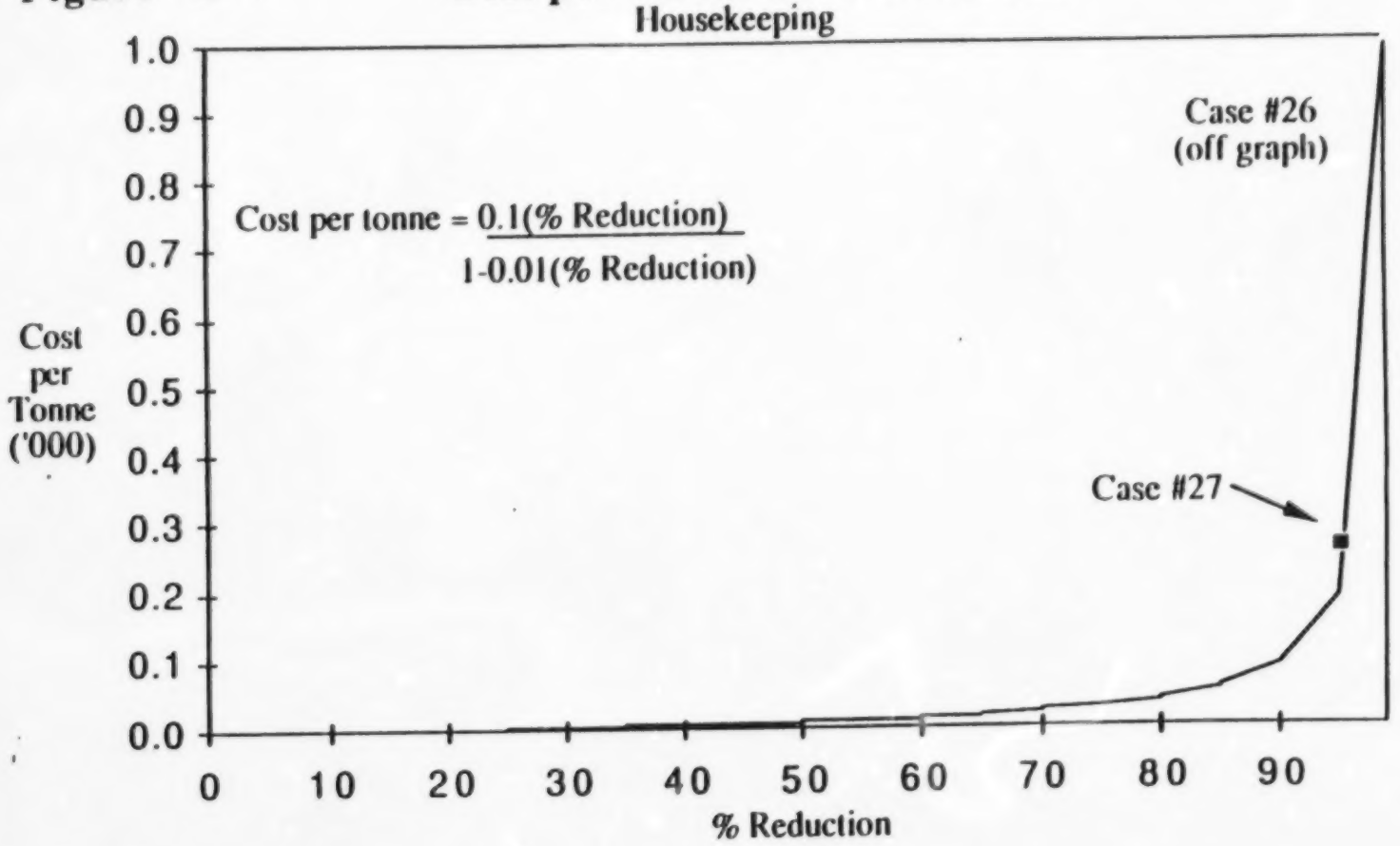

Figure B-5 Linearized Cost vs % Reduction Curves
For Specific Techniques & Composite